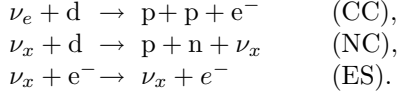


# Direct Evidence for Neutrino Flavor Transformation from Neutral-Current Interactions in the Sudbury Neutrino Observatory[1]

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The Sudbury Neutrino Observatory (SNO) detects  $^8\text{B}$  solar neutrinos through the reactions:



The CC reaction only involves electron-type neutrinos, while the NC reaction is equally sensitive to all active neutrino flavors ( $x = e, \mu, \tau$ ). The ES reaction is sensitive to all flavors as well, but with reduced sensitivity to  $\nu_\mu$  and  $\nu_\tau$ . These three reactions allow SNO to determine the electron and non-electron active neutrino components of the solar flux [2]. This note presents the first NC results and updated CC and ES results from SNO.

SNO [4] is a water Cherenkov detector located at a depth of 6010 m of water equivalent in the INCO, Ltd. Creighton mine near Sudbury, Ontario, Canada. The detector uses ultra-pure  $\text{D}_2\text{O}$  contained in a transparent acrylic spherical shell to detect solar neutrinos. Cherenkov photons generated in the  $\text{D}_2\text{O}$  are detected by 9456 PMTs mounted on a stainless steel geodesic designed, constructed and installed by the LBNL group. The geodesic is immersed in ultra-pure  $\text{H}_2\text{O}$  to provide shielding from radioactivity.

The data reported here were recorded between 11/2//99 and 5/28/01 and represent a total of 306.4 live days in which only  $\text{D}_2\text{O}$  was present in the sensitive volume. The analysis procedure was similar to that described in [3]. PMT times and hit patterns were used to reconstruct event vertices and directions and to assign to each event a most probable kinetic energy,  $T_{\text{eff}}$ . The total flux of active  $^8\text{B}$  solar neutrinos with energies greater than 2.2 MeV was measured with the NC signal (by the 6.25 MeV  $\gamma$  ray from neutron capture on deuterium). The analysis threshold was  $T_{\text{eff}} \geq 5$  MeV. Above this energy threshold, there were contributions from CC events in the  $\text{D}_2\text{O}$ , ES events in the  $\text{D}_2\text{O}$  and  $\text{H}_2\text{O}$ , capture of neutrons (both from the NC reaction and backgrounds), and low energy Cherenkov background events.

A fiducial volume was defined to only accept events which had reconstructed vertices within 550 cm of the detector center to reduce external backgrounds and systematic uncertainties associated with optics and event reconstruction near the acrylic vessel. The energy calibration was updated from [3] with LBNL's  $^{16}\text{N}$  calibra-

tion source [5] data and Monte Carlo calculations.

The electron neutrino flux was measured to be  $1.76 \pm_{0.05}^{0.05} (\text{stat.}) \pm_{0.09}^{0.09} (\text{syst.})$  and the non-electron flux was found to be  $3.41 \pm_{0.45}^{0.45} (\text{stat.}) \pm_{0.48}^{0.48} (\text{syst.})$  [1]. Figure 1 shows the deduced flux of non-electron flavor active neutrinos vs the flux of electron neutrinos.

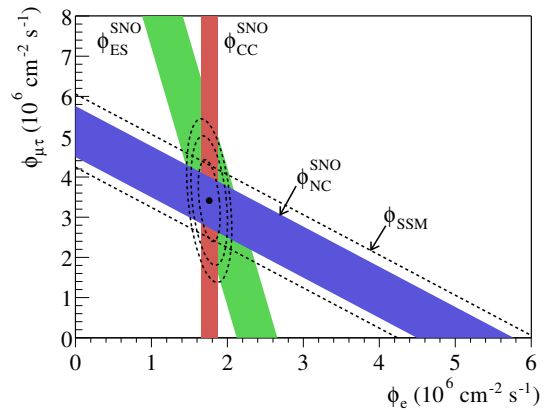


FIG. 1: Flux of  $^8\text{B}$  solar neutrinos which are  $\mu$  or  $\tau$  flavor vs flux of electron neutrinos deduced from the three neutrino reactions in SNO. The diagonal bands show the total  $^8\text{B}$  flux as predicted by the SSM and that measured with the NC reaction in SNO (solid band). The bands intersect at the fit values for  $\phi_e$  and  $\phi_{\mu\tau}$ , indicating that the combined flux results are consistent with neutrino flavor transformation assuming no distortion in the  $^8\text{B}$  neutrino energy spectrum.

These results are the first direct measurement of the total flux of active  $^8\text{B}$  neutrinos from the sun and provide strong evidence for neutrino flavor transformation. The CC and ES reaction rates are consistent with the earlier results [3] and with the NC reaction rate under the hypothesis of flavor transformation. The total flux of  $^8\text{B}$  neutrinos measured with the NC reaction is in agreement with the SSM prediction.

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